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CHARACTERISTICS OF BACK-PACK PUMPS USED IN FOREST FIRE SUPPRESSION

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by
J. S. Mactavish

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CORRECTION

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The caption below Figure 13 on page 20 should read:

Figure 13. Unit "G" nozzle assembly. (1) Trigger, (2) Trigger-operated valve pin, (3,5) Leather washers, (4) Outlet valve body, (6-9) Adjustable nozzle, (10) Leather washer, (11) Nozzle cap.

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CHARACTERISTICS OF BACK-PACK PUMPS USED IN FOREST FIRE SUPPRESSION

by

J. S. Mactavish[1]

INTRODUCTION

A back-pack pump is defined as a small water container of metal or canvas equipped with a hand pump and fitted with back-pack straps. Such pieces of equipment are commonly used in all stages of forest fire suppression from initial attack to mop-up. Several new models have recently appeared on the market and it is thought desirable to examine some of them, as well as some of the older makes, to determine their characteristics and capabilities.

Data for this report were obtained at a temporary forest fire research station of the Forestry Branch at Whitecourt, Alberta, during the fire seasons of 1954, 1955, and 1956. Each unit examined was put through several tests to determine its performance capabilities and was used in the normal routine of the research station to extinguish test fires. Pumps tested were disassembled and examined for any inherently weak components, for significant characteristics of design and manufacture, and for frequency and simplicity of maintenance required. Many of the good and poor points of the various units were brought to light by this procedure.

It should be borne in mind that the pumps of some makes may be readily fitted to the tanks of others so that various combinations may be used to make up back-pack pumps to meet special needs. The pumps tested are shown in Figure 1; included are those most commonly used for forest fire suppression in Canada, as well as others that have become available in recent years. Each make or type is referred to in this report by one of the letters "A" to "G".

Figure 1. The seven back-pack pumps examined and reported on in this study.

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No unit was thought to be outstanding. All are suitable for certain specific purposes, but for general use some are better than others. The major physical and performance characteristics are summarized in Table 1.

TABLE 1. SUMMARY OF PHYSICAL AND PERFORMANCE CHARACTERISTICS

Unit	Dry Weight (lbs.)	Tank Capacity (imp. gals.)	Type of Pump	Effective Stream Length (feet)	Volume Discharged in 25 Pump Cycles (imp. gals.)
A	9.4	3.2	Trombone Single Action	32	0.50
B	11.1	4.4	Trombone Single Action	34	0.60
C	12.2	4.0	Trombone Single Action	42	0.48
D	11.3	3.4	Trombone Double Action	27	0.54
E	10.8	4.3	Trombone Continuous Action	31	0.55
F	11.6	4.3	Trombone Double Action	32	0.45
G	16.1	3.6	Lever Continuous Action	25	0.28

Table 2 (beginning on p. 21) gives specifications and characteristics of these back-pack pumps so that direct comparison between the various models may be readily made.

WATER CONTAINERS

A back-pack pump consists of three major components: water container, hose, and pump. The efficiency of a unit depends upon its weakest component, the failure of which detracts from any special characteristics of the other components.

There are two principal types of water container—the rigid walled tank and the collapsible water bag. Tanks are generally quite rugged and will stand considerable abuse. They are particularly useful for purposes of initial attack since they can be filled with water and stored in caches or vehicles. The collapsible water bags, sometimes referred to as "geikie" bags, were not included in this investigation. Made either of canvas with a rubber lining or neoprene-coated fabric, they have about the same capacity as the metal tanks and are most useful when it is necessary to economize on storage space.

Construction

Although experimental tanks have been made with plastics and fiberglas, the most common material is galvanized steel. An inner coating of a corrosion preventive is sometimes used, but all tanks of metal construction are subject to rusting when these treatments become chipped or scratched. One of the models tested rusted through in less than a year.

Hand tanks should be of welded construction, strong enough to withstand rough usage on the fire line. All models tested have a flange or skirt to protect the base of the tank when it is being transported. The benefit of centre baffles, installed to lessen the movement of water when the units are back-packed, is questionable. The construction of all tanks was considered adequate, but use of a material not subject to corrosion would be desirable.

Capacity

One of the more important characteristics of a back-pack tank is its capacity. Although it is desirable to have a large volume, the loaded or gross weight must not reduce the efficiency of the fire fighter. None of the units tested was considered too heavy. Tank capacities range from 3.2 to 4.4 Imperial gallons (Table 1). A tank holding 4.0 to 4.5 gallons should prove most suitable for fire fighting. Those with smaller capacities require more frequent filling and those over 4.5 gallons would be too heavy for steady use by most fire fighters.

The ratio between the weight of water carried, 10 pounds per gallon, and the total weight of the full unit is of interest when comparing different makes. The tank should be as light as possible, but not at the expense of ruggedness. With few exceptions, the larger tanks have the higher ratios of weight of water capacity to gross weight. Among the models examined, this ratio ranged from 0.69 to 0.80, with Units B and F having the best ratios (Table 2).

Filling Opening

There are several features of the tank filling opening which, taken together, make up the most efficient filling system. The opening must be large enough to permit rapid filling with a bucket, and must be close to the edge of the tank to permit filling from shallow water. The opening must be fitted with a strainer of sufficiently small mesh to prevent pump blockage, but of a type that will not impede the flow of water into the tank. A cylindrical or conical brass wire strainer extending at least two inches into the tank is best. Steel wire strainers are not satisfactory because they will eventually corrode and broken pieces may clog the pump. Finally, the strainer must have some device to hold it firmly in place.

Unit D can be most easily filled from shallow water sources as its opening is closest to the tank edge, $\frac{7}{8}$-inch, and its tank length is only $12\frac{3}{4}$ inches. Unit A, at the other extreme, has its filling opening in the centre of the top, $2\frac{3}{4}$ inches from the edge, and it also has the longest tank of those tested, $17\frac{7}{8}$ inches.

The strainer of only one model, Unit A, is considered satisfactory. It has a cylindrical brass wire strainer that permitted rapid filling, and no pump blockage was noted during the test period. Perforated copper plates are used for strainers on some units. The holes in the plates are both too large and too few for satisfactory service.

Two of the seven models, C and G, have no device to hold the strainer in place. This makes the strainer vulnerable to loss, especially when the tank is being dip-filled.

Lids of the filling opening on four of the units are fitted with threaded caps while the others have friction and/or clamped lids. All have rubber gaskets except the friction lid of Unit B. All tanks lose some water through their air vents when being back-packed nearly full.

An important although minor feature is the attachment of the filling opening cap to the tank. All except Unit A have provision for attaching the cap by chain or cord.

Tank Outlet

The type and position of the tank outlet is important. An outlet through the top, found on Units A, D, and G, should prove most serviceable. Tanks so

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equipped take up somewhat less space in a cache or truck and are less susceptible to damage. They may also reduce the chance of sediment blocking the nozzle.

The outlets of the other units protrude from near the base of one side of the tanks where they are subject to damage if the tank is dropped or knocked. In one model, Unit C, the outlet assembly is removable for cleaning the outlet filter screen or for replacing it. Some models have no filter at the outlet (Table 2).

Carrying Features

Since all back-pack pumps are heavy when full, it is desirable that they be designed to be easily carried by hand or on the back. A collapsible handle is convenient for hand carrying. For back-packing, the straps must have adjustable lengths and should be equally spaced at the top and bottom of the tank to lessen irritation. The pump barrel should be mounted vertically at the side of the tank.

All units tested are provided with carrying handles which in most instances also serve as clamps to hold the pump. This arrangement is satisfactory for carrying the units by hand but, as described below, it has definite disadvantages when the units are back-packed. The collapsible handles of Units A and B are satisfactory. The fixed pump-clamp-handle of Unit F is unsatisfactory because of insufficient hand room between the handle and the tank.

One disadvantage in having the clamp-handle fixed to the top of the tank is that back-pack pumps so equipped cannot be stacked satisfactorily for storage. More important is the difficulty encountered when the operator attempts to remove the pump from its clamp when the unit is mounted on his back. Considerable contortion is required to grasp the pump barrel and then pull it free. This problem is overcome on two models, A and G, the first of which has movable pump clamps mounted on the side of the tank, while the second has no external pump barrel. It would be advantageous to have clips on the carrying straps and rings on the pump barrel so that the pump could be carried across the chest of the operator when not in use. This system was used by at least one manufacturer in the past, but has apparently been discontinued.

Some pumps are too long for convenient handling. The operator may find it awkward to use the full length of stroke required for maximum performance, and, when the units are being back-packed through the woods, the protruding pumps tend to catch in surrounding branches. The over-all length of pump should not exceed about 20 inches. The pump barrels of Units B, C, and E are considerably longer than the other models; however, the over-all pump length of Unit C has been kept to a minimum by employing a hollow metal hand grip attached to the piston so as to fit back over the cylinder (Figure 9).

All models are equipped with carrying straps of adjustable webbing clipped to the top and bottom of the tank. Five of the models examined are difficult to mount unassisted, when filled. The difficulty is encountered after the operator has used one strap to swing the tank onto his back, and must then attempt to get his free arm through the other strap. A cylindrical tank that will roll across the operator's back permits him to put his arm through the loop of the second strap more easily than does the more common rectangular tank. A very simple and effective means of overcoming the trouble is found on Unit G, on which only one of the straps is permanently fixed to the tank at both ends; the other,

fixed to the top of the tank, has a metal hook at the bottom edge. Afer swinging the tank up by the first strap, the operator merely has to pull the other strap over his shoulder and hook it under the tank skirt.

The carrying straps on several models tend to irritate the shoulders of operators, since the strap connections at the top of the tank are too close together. Straps spaced about equally at both top and bottom, as on Unit A, are more comfortable.

All manufacturers claim special features such as "form-fitting" and/or double tank backs designed to make back-pack pumps more comfortable to pack. A double back may shield the operator from the cold tank surface to a certain extent, but it will not keep his back dry and adds additional weight. The lighter units were considered the most comfortable, regardless of shape.

In general, there are few major differences between the tanks of the various back-pack pumps examined. The tank of Unit A might rate slightly higher than the others as it is cylindrical and fairly comfortable to pack; furthermore the pump may be more readily reached and pulled from its clamps than that of other models. With its outlet at the top it is less susceptible to damage and takes up a minimum of storage space. On the other hand, it has the smallest capacity of the group and required the deepest water source for filling by dipping.

HOSE

Of the seven units reported on, five have rubber hose reinforced with cord, one has an unreinforced rubber hose, and one a plastic hose. Reinforced rubber hose is the most reliable of those types tested. Both the unreinforced rubber hose, Unit B, and the plastic hose, Unit D, failed during tests. The rubber hose tore at the tank outlet and both split at the pump connection. The plastic hose also becomes stiff and unmanageable at low temperatures.

Sufficient length of hose should be provided to permit ready use of the pump either with the tank on the ground or mounted on the operator. The length of hose required depends upon the location of the tank outlet nipple and the length of the pump barrel; however, about 35 inches of strong supple hose should be satisfactory. Units B, C, and E are rather difficult to operate when the tanks are on the ground because of the short hoses provided. The operator is forced to bend over to use the pump and, if the outlet is not pointed directly toward the fire, the hose is liable to kink, cutting off the water supply.

Most models employ the familiar ridged hose-connecting nipple, both on the tank and on the pump barrel, onto which the hose is forced, usually with some difficulty, and then clamped. The ends of the hose become stretched slightly and, in time, will split and require refitting. These rigid connections sometimes cause hose kinking when the pump is in use, especially when the tank is on the ground.

A recent innovation is the use of snap-on couplings found on Units A and D, both of which have outlets at the top of the tanks. Advantages of snap-on connections are that they are readily coupled and the swivel joints minimize hose kinking. Although neither coupling broke down, both showed evidence of wear at the end of the three-year test period. The coil spring around the outside of the coupling of Unit A, which ensures a tight connection, is made of steel and was beginning to corrode. The copper spring in the interior of the coupling

of Unit C had stretched out of shape. The advantages of snap-on connections generally outweigh their disadvantages, however, and they are preferable to the usual nipple and clamp arrangement.

HAND PUMPS

Operating Principles

Although all but one of the back-pack pumps tested employ the same basic pump mechanism—an outer cylinder or barrel with inlet check valve, and an inner plunger with outlet check valve—there are differences in quality, performance, and price which should be considered before selection of any one make. Price is not considered here since it may vary from time to time and with the size of purchase orders.

Six of the seven pumps tested are trombone types, three being single action, two double action, and one continuous action. The seventh, a lever action pump, delivers water either continuously or intermittently through a triggered nozzle. The relative merits of the systems are discussed before proceeding to the details of the individual units tested.

Figure 2 (i-iii) depicts the operating principles of a single action pump equipped with a piston ring. With the suction stroke a partial vacuum is created which helps close the outlet valve in the plunger (c), opens the inlet valve (f), and draws water into the pump. With the compression stroke, the pressure of the water in the cylinder closes the inlet valve, opens the outlet valve, and the water is forced through the plunger and out the nozzle. Figure 2 (iv) shows a single action pump equipped with packing at the cylinder mouth. Operating principles are the same as for those with piston rings.

In double action pumps (Figure 3), the suction stroke is similar to that of a single action pump, but on the compression stroke, only a portion of the water moves through the plunger and out the nozzle. The rest of the water passes through openings in the plunger walls and into the space within the outer cylinder surrounding the plunger. On the next suction stroke water is once again drawn into the pump barrel. At the same time the water surrounding the plunger in the forward portion of the pump is put under compression by the forward moving piston ring and is forced back through the holes into the plunger and out the nozzle.

It is evident that a double action pump requires two strokes to expel the same quantity of water that it would expel with one compression stroke were it a single action unit with a piston ring. The equivalent of all the water drawn into the pump on the suction stroke would be expelled during the following compression stroke rather than be partly diverted out of the plunger and into the area surrounding it, only to be forced back again and expelled on the following suction stroke. The resulting turbulence makes this type of pump more difficult to operate than the single action models tested.

The pump action shown in Figure 4 is known as continuous action. The suction stroke draws water into the pump in the same manner as described above. On the compression stroke, the outlet valve opens and the water enters the plunger. Part of the water enters the small inner tube and is expelled through the nozzle while the remainder fills the space in the plunger surrounding the inner tube. At the same time a small pocket of air is trapped and compressed at the nozzle end of the plunger. When compression is released as the suction stroke is applied, this air expands, forcing the water around the inner tube to be

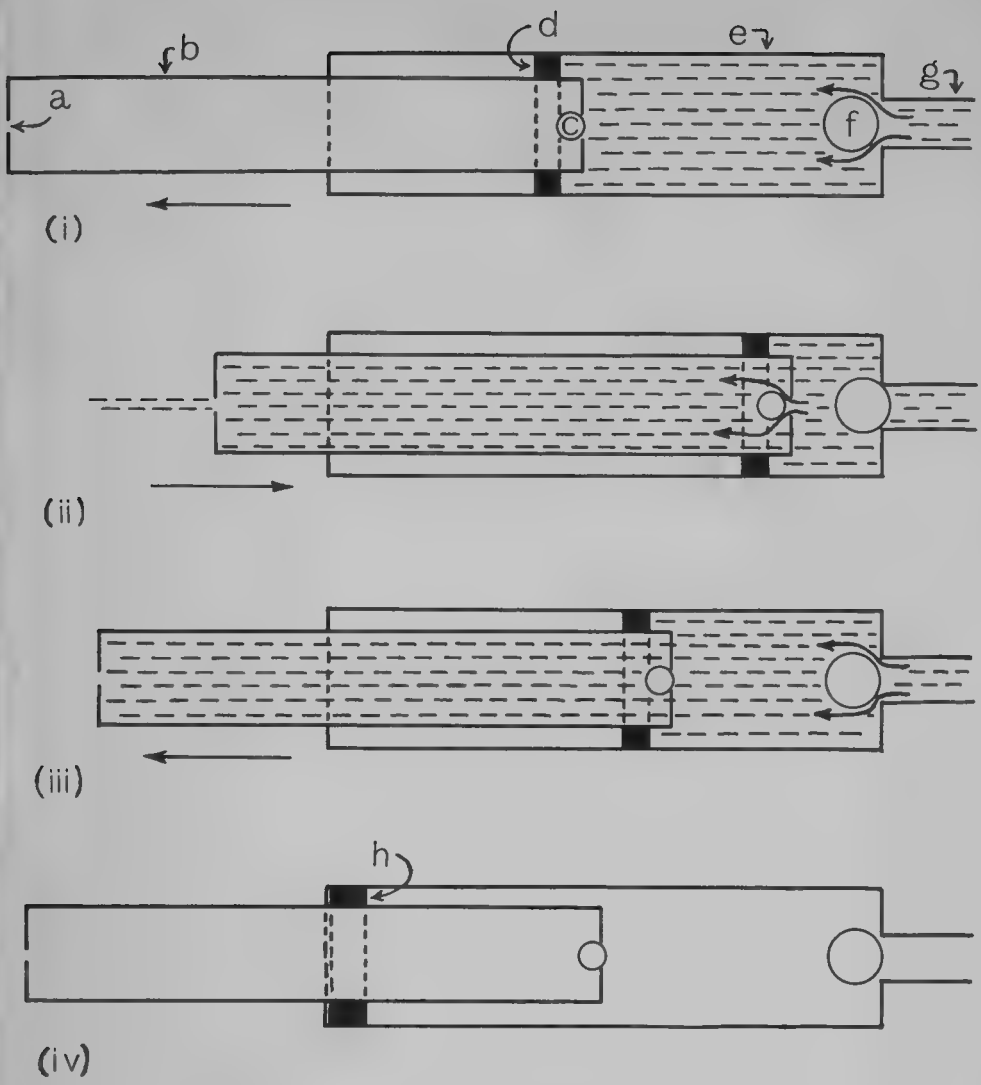


Figure 2. Single action pump. Sections i-iii, operation of piston ring equipped model. Section iv, model equipped with packing. (a) nozzle, (b) plunger, or piston, (c) outlet check valve, (d) piston ring, or packing, (e) barrel, or cylinder, (f) inlet check valve, (g) inlet nipple, (h) barrel gland packing.

expelled through the tube. At the same time, a new supply is being drawn into the pump. In this manner a continuous stream should issue from the pump during its operation. It was found, however, that the continuous action is obtainable only when the nozzle end of the pump is pointed upward. If the nozzle were to be pointed down, the air pocket trapped at the mouth of the plunger would move toward the base of the pump and, as a result, there would be nothing to force the water within the plunger to move out of the inner tube after the compression stroke was completed. Although this type of pump may yield a continuous flow of water on both the compression and suction strokes, it must be borne in mind that the total amount of water produced on the two strokes does not exceed the amount that would be produced if the small bore

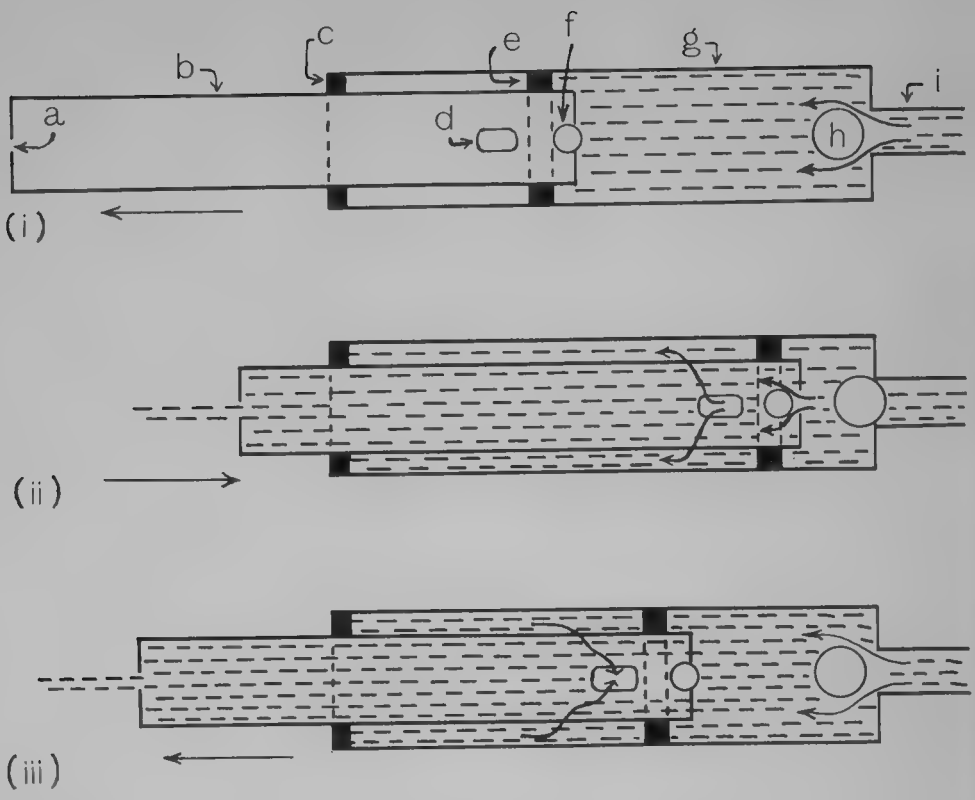


Figure 3. Double action pump. (a) nozzle, (b) plunger, or piston, (c) barrel gland packing, (d) bypass port in piston, (e) piston ring, or packing, (f) outlet check valve, (g) barrel, or cylinder, (h) inlet check valve, (i) inlet nipple.

inner tube were absent and the pump were of the single action variety. The primary disadvantage of the continuous action system is that the pressure behind the stream is not constant; consequently, some of the water may not reach the target. No particular advantage was found with this system during the test period.

In the lever action pump (Figure 5), the pumping lever, not shown, is linked to the plunger in the tank so that when the lever is moved back and forth the plunger is raised and lowered. On the lower end of the plunger there is a rubber cap, which fits snugly into the pump cylinder. Water in the tank runs into the cylinder by gravity when the plunger is raised and on the compression stroke this water is forced into the main body of the plunger, some of it going up the outlet tube. As more and more water enters the plunger on successive strokes, the air within it is put under greater pressure which, of course, increases the nozzle pressure. This type of arrangement yields a continuous stream, the pressure depending on the intensity of the pumping action. If desired, the nozzle may be left closed while pumping so that pressure which could be used later is built up in the system. This type delivers a shorter stream than is obtained with trombone-type pumps and requires more pumping to discharge a given amount of water (Table 1).

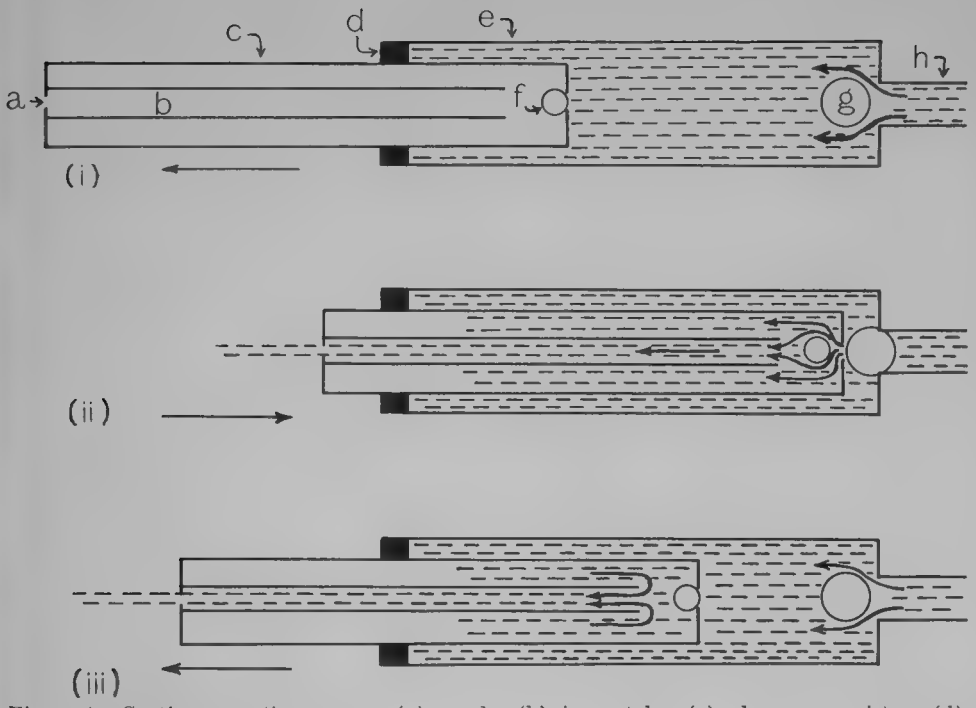


Figure 4. Continuous action pump. (a) nozzle, (b) inner tube, (c) plunger, or piston, (d) barrel gland packing, (e) barrel, or cylinder, (f) outlet check valve, (g) inlet check valve, (h) inlet nipple.

Piston Rings and Packing

In a hand pump, the component most subject to wear is the sealing material used to ensure suction and pressure when the pump is operated. Single action pumps require sealing at one end only, either a piston ring on the end of the plunger or packing at the nozzle end of the cylinder. The locations are pictured in Figure 2, sections i and iv, respectively. Double action pumps must be watertight at both the cylinder mouth and at the intake end of the plunger, as shown in Figure 3.

The sealing material used may consist of grease-impregnated cord, leather washers, or neoprene rings, usually referred to as "O" rings. The last are considered the best, since they required the least servicing during the test period. They are also the easiest to service. It has been claimed that the neoprene rings tend to harden and become brittle, but this was not noted. As long as pumps were well lubricated, all the piston rings and packings studied gave good service. The manufacturer should be consulted as to the proper lubricant to be used.

Maintenance consists largely of cleaning the pump, lubricating, and replacing worn piston rings and packing. It is simple and inexpensive to replace the neoprene rings. Leather washers require more care since they must first be soaked with lubricant. The cord-type packing, used on Units C and E, is the most difficult to change. Several turns of a round, braided, graphite-impregnated cord are wrapped around the pump plunger of Unit C. A thin brass washer on one side prevents the packing from becoming entangled in a shock absorber spring, but only the cylinder cap holds the other side in place. When the plunger is removed from the pump cylinder for cleaning, the cord frequently unravels and

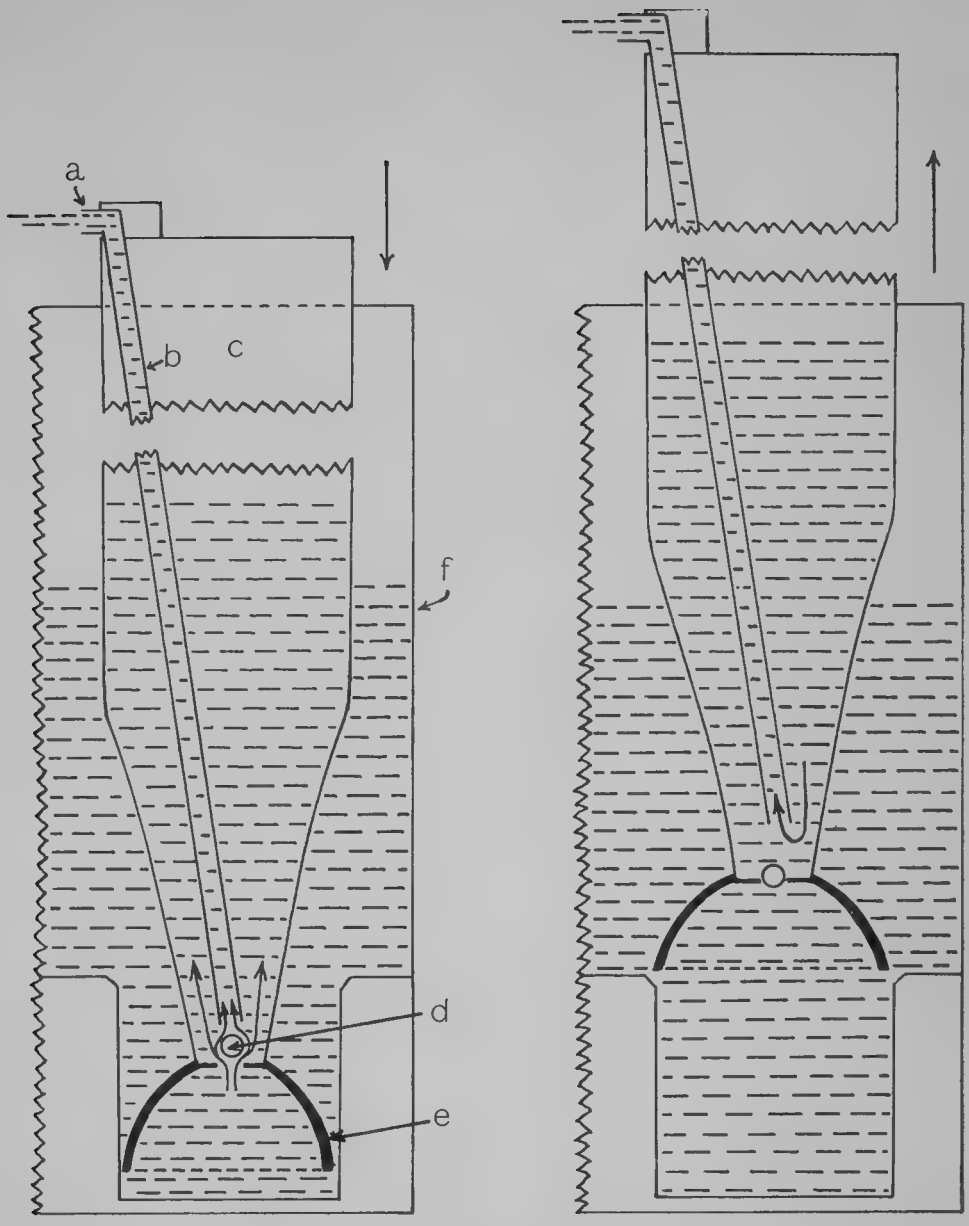


Figure 5. Lever action pump. (a) nozzle hose connection, (b) outlet tube, (c) plunger (operated by lever action, not shown), (d) inlet check valve, (e) rubber piston cup, (f) portion of back-pack tank.

is difficult to rewind or replace tightly enough to fit between the plunger and the cylinder walls. It must often be forced in by screwing the cylinder cap down upon it, which may result in the cord being caught and frayed in the screw-thread of the cylinder mouth. An internal ridge around the cylinder near its mouth prevents the packing from moving down the cylinder. The cord used on Unit E is similar to that of Unit C, but is square in cross section and therefore more easily wound tightly about the plunger. It is encased between two $\frac{3}{8}$-inch

brass sleeves and tends to adhere to them; consequently, when the cylinder cap is removed and the plunger pulled out, the packing seldom unravels.

Pump cylinders of models which do not use piston rings can stand a considerable amount of abuse before their performance is affected, whereas a slight dent in the cylinder wall of a pump equipped with a piston ring may render the pump useless.

Inlet Valve

Ball-type inlet valves are used on all pumps that were examined. In trombone-type pumps the valve body is the tail-end piece of the cylinder. Made of brass, the ball is usually held in place by a metal bar, but in one case, Unit D, a perforated plastic shield is used at the mouth of the valve body. A glass ball seated over the piston cup is used on Unit G, the lever action pump.

A properly functioning inlet valve opens freely when a partial vacuum is created by the suction stroke, thereby permitting water to be drawn into the pump barrel; and when the compression stroke is applied, the valve must close tightly, preventing water from returning to the tank. The valves on all models gave trouble-free service throughout the test period.

Outlet Valve

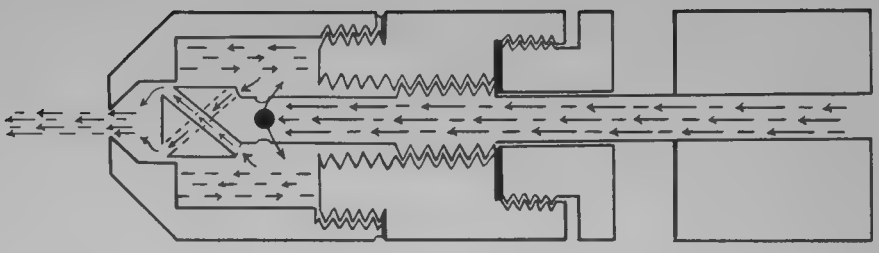
The outlet check valve is one of the most important components of a hand pump. It should open readily on the compression stroke and close rapidly and tightly when the pump action is stopped, otherwise the pump and hose may act as a siphon tube and drain water from the tank. In many forest fire situations water is difficult to get and such wastage must be avoided.

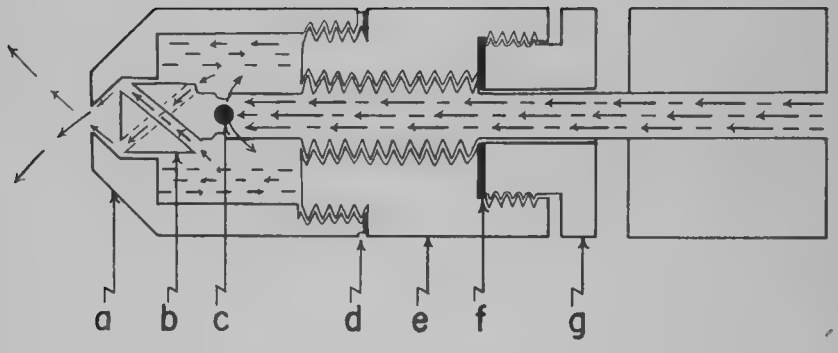
In all but the lever action unit the outlet valve body is in the tail-end piece of the pump plunger. It is threaded to the plunger and, except in double action pumps, is fitted with a cross-pin or shield used to retain the valve spring. In the double action models, tabs cut from the plunger wall are bent inward to retain the valve spring and ball. The function of the valve spring is to hold the ball tightly against the port except during compression strokes. If the spring is not strong enough, water may siphon from the tank. Springs are made of steel or copper and should be examined frequently for corrosion or weakening to permit replacing before they break and block passages in the pump. This is particularly important for steel springs. The outlet valves of Units A and C were the only ones that worked properly throughout the test period. The sample of Unit F had no valve spring and those of B, E, and, to a lesser extent D, were too weak to close the valves effectively.

The outlet valve of the lever action model, G, is in the nozzle. A trigger is connected to a brass rod that has a conical end that fits into the outlet valve. A copper coil spring is fitted over the pin to ensure quick and complete closure of the valve when the trigger is released. The valve did not leak during field trials.

Nozzles

The seven pumps under discussion had three general types of nozzle—adjustable, interchangeable, and straight stream. A representative of each is described here. Specific details pertaining to individual models are recorded elsewhere (Table 2).





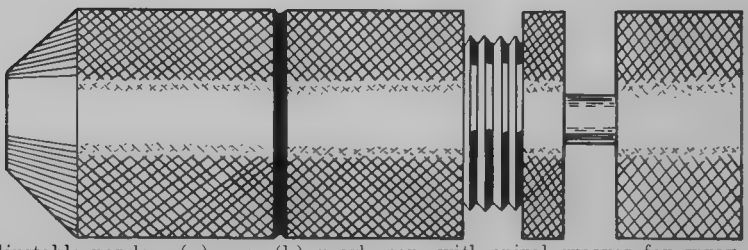


Figure 6. Adjustable nozzle. (a) cap, (b) nozzle core with spiral grooves for spray stream, (c) water passage, (d) washer, (e) stream adjuster, (f) packing, (g) packing nut.

A typical adjustable stream nozzle assembly is shown schematically in Figure 6. Near the closed tip of the hollow stem, water passes through four holes (c) at right angles to the normal flow in the pump. It then passes around the stem tip (b) through special grooves when set for spray, and issues through a small opening in the conical spray cap (a). The spray cap is usually threaded to a stream adjuster (e) which in turn is threaded to the nozzle stem. As the stream adjuster is turned in a clockwise direction the spray cap moves away from the grooved nozzle tip and a straight stream is obtained.

The obvious advantage of an adjustable stream nozzle is the conservation of water made possible by its judicious use. There is a definite disadvantage, however, in that this type of nozzle is easily blocked with small particles because of the several small water passages and the changes in direction in the flow of water.

The interchangeable nozzle is not as versatile or as complex as the adjustable nozzle. It provides either a straight stream or one particular spray pattern. A common type is essentially a double nozzle, and to change stream patterns one side of the nozzle must be unscrewed from the pump and the other screwed into place. The assembly is usually attached to the pump by a chain, at least one end of which should be fitted with a free-turning ring so that the chain will not twist when the nozzle is being turned.

Straight stream nozzles are merely attachments to the pump end to provide a small orifice, thereby increasing the length of stream. The versatility of these nozzles may be greatly increased by the addition of a thumb operated deflector as shown with Unit C in Figure 9. The nozzle of Unit A has a snap-on coupling so that a spray attachment can be used as required.

During the tests of the seven models only those with straight stream nozzles gave trouble-free service. Frequent blockage of the nozzle was encountered with all the others, even when relatively clean water was used.

PERFORMANCE

All the pumps examined were given a series of performance tests to determine their maximum length of stream, effective length of stream, and volume output. The maximum length of stream was taken simply as the distance from the pump to the furthest point of deposition. The length of effective stream was arbitrarily considered to be the distance from the pump to the furthest point at which the ground was almost completely covered with water drops after 25 pumping strokes.

Volume production (Table 1) was measured as the average amount of water produced in 25 pump cycles, a pump cycle being a suction stroke followed by a compression stroke.

All tests were done on level, sandy ground and on calm days. To simulate conditions in the field, the tests were carried out with the back-pack pump mounted on the operator. Several operators tested each unit and the results shown in Tables 1 and 2 are average figures, except for maximum length of stream.

Unit C yielded results for both maximum length of stream and effective length of stream which were significantly greater than those of the other models. The differences between units in the volume test were minor except for Unit G which yielded a significantly lower output than the others.

SUMMARY

During the 1954 to 1956 forest fire seasons, seven different back-pack pumps were tested to determine their characteristics and capabilities. None of the units had all the more desirable features.

All the tanks were considered to be reasonably well made but were somewhat uncomfortable to back-pack. A common fault found on five models was the position of the pump clamps—on the tops of the tanks. For greatest ease of operation the pump should be mounted vertically on one side of the tank.

Only one tank had a satisfactory strainer in the filling opening. For best results, the strainer should be a conical or cylindrical brass wire screen extending several inches into the tank. The strainer must not permit the passage of material large enough to block the pump; nor should it impede the flow of water into the tank.

The most desirable position of the tank outlet is at the top where it is least susceptible to damage. Three units had this type of outlet.

A supple, reinforced rubber hose about 35 inches long is the most satisfactory for general use. Hoses on several models were both too stiff and too short. The plastic hose of one model examined was unsatisfactory.

The least complex type of pump, single action with straight stream nozzle, appeared to be most suitable for general fire-fighting purposes. Double action pumps required more effort to operate than single action units. The lever action pump tested did not produce a stream of sufficient length for fire line use.

Spray or adjustable stream nozzles are quite susceptible to blockage by small particles capable of passing through the tank strainer. The simple

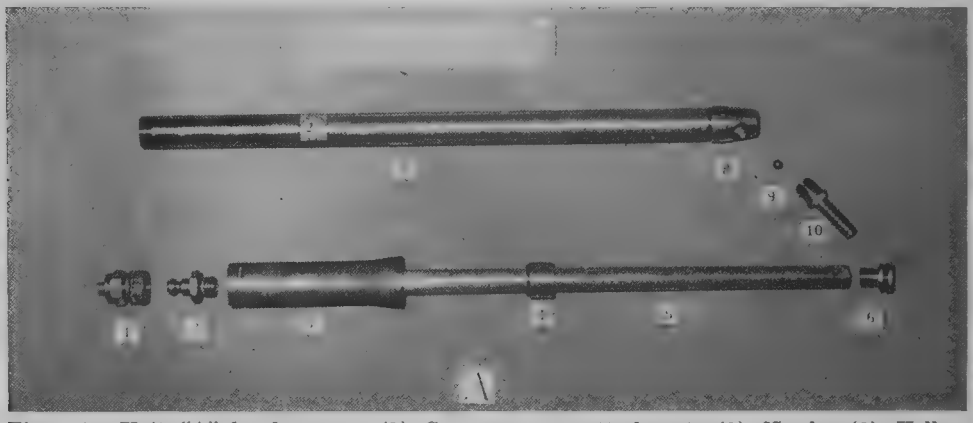


Figure 7. Unit "A" hand pump. (1) Snap-on spray attachment, (2) Nozzle, (3) Hollow hand-grip, (4) Cylinder cap containing felt wiping ring, (5) Plunger, (6) Outlet valve assembly with neoprene piston ring, (7) Cylinder, (8) Cylinder tail-end piece, (9) Inlet valve ball, (10) Inlet valve body and hose connection (not the usual snap-on coupling). Note 6-inch rule.

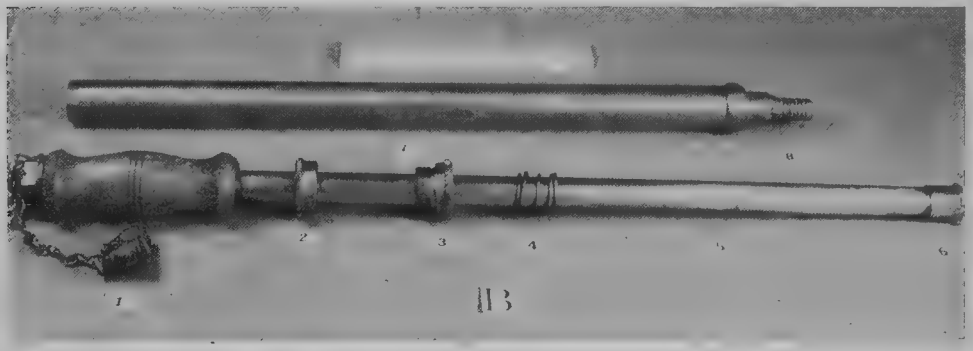


Figure 8. Unit "B" hand pump. (1) Interchangeable nozzle, chain not attached to free-turning ring, (2) Packing gland nut containing packing ring, (3) Packing nut, (4) Shock absorber spring, (5) Plunger, (6) Outlet valve assembly, (7) Cylinder, (8) Inlet valve assembly and hose nipple.

straight-stream nozzle is unlikely to become blocked even with relatively dirty water. Either a tongue stream-deflector or a spray-tip attachment on this type of nozzle will permit a range of stream patterns sufficient for most purposes.

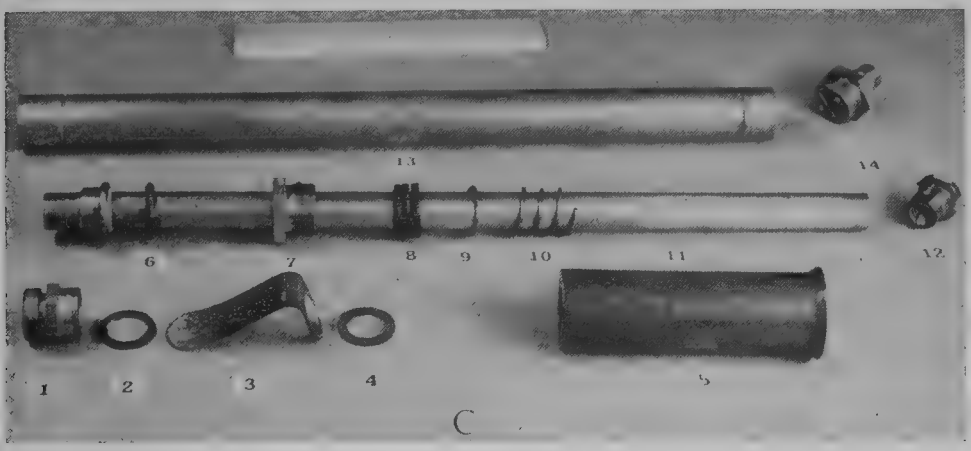


Figure 9. Unit "C" hand pump. (1) Straight stream nozzle, (2) Leather washer, (3) Tongue stream-deflector, (4) Leather washer, (5) Hollow hand-grip, (6) Rubber shock absorber ring, (7) Packing nut, (8) Cord packing, (9) Brass washer, (10) Shock absorber spring, (11) Plunger, (12) Outlet valve assembly, (13) Cylinder, (14) Inlet valve assembly.

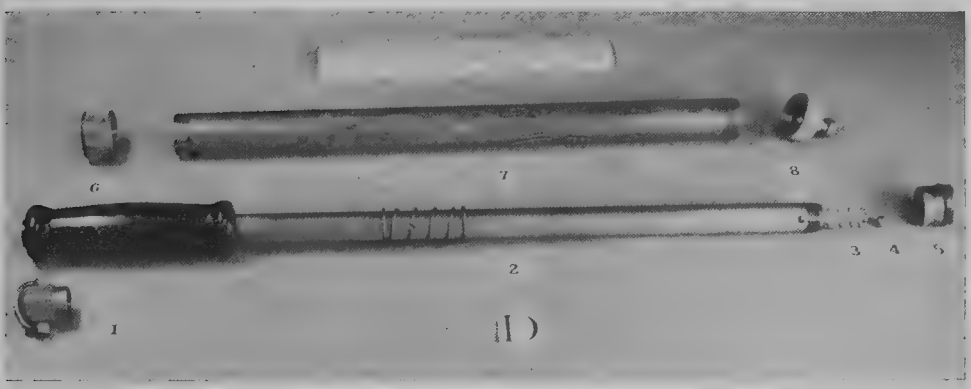


Figure 10. Unit "D" hand pump. (1) Interchangeable nozzle with revolving pin, (2) Plunger with shock absorber spring, (3) Outlet valve spring, note spring-retaining tabs as bent-in sections of plunger wall, (4) Outlet valve ball, (5) Outlet valve body with neoprene piston ring, (6) Cylinder cap containing neoprene packing ring, (7) Cylinder, (8) Inlet valve assembly and snap-on hose coupling.

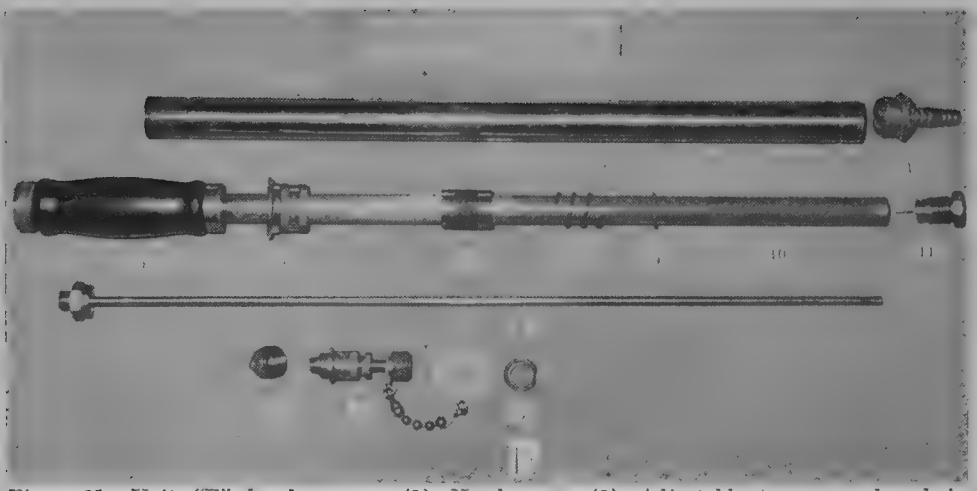


Figure 11. Unit "E" hand pump. (1) Nozzle cap, (2) Adjustable-stream nozzle, chain attached to free-turning rings, (3) Leather washer, (4) Inner tube, (5) Hand grip, (6) Packing nut, (7) Cord packing bounded by brass sleeves, (8) Shock absorber spring, (9) Brass washer, (10) Plunger, (11) Outlet valve assembly, (12) Cylinder, (13) Inlet valve assembly and hose nipple.

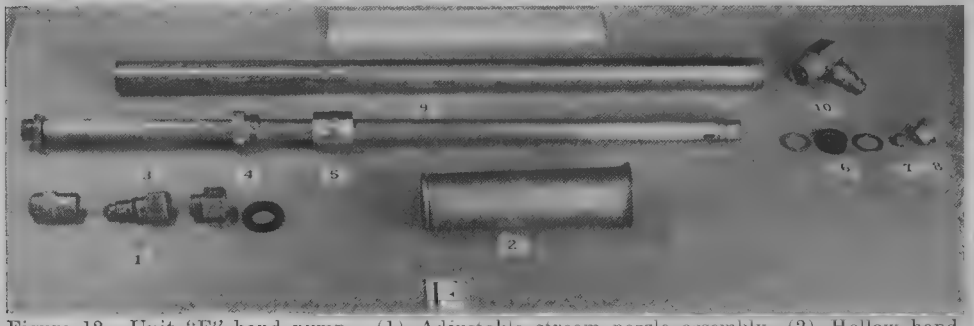


Figure 12. Unit "F" hand pump. (1) Adjustable stream nozzle assembly, (2) Hollow hand-grip, (3) Plunger, (4) Packing nut, (5) Packing gland containing leather washers, (6) Leather washers bounded by brass washers, (7) Outlet valve ball, note ball-retaining tabs as bent-in sections of plunger wall, (8) Outlet valve body, (9) Cylinder, (10) Inlet valve assembly and hose nipple.

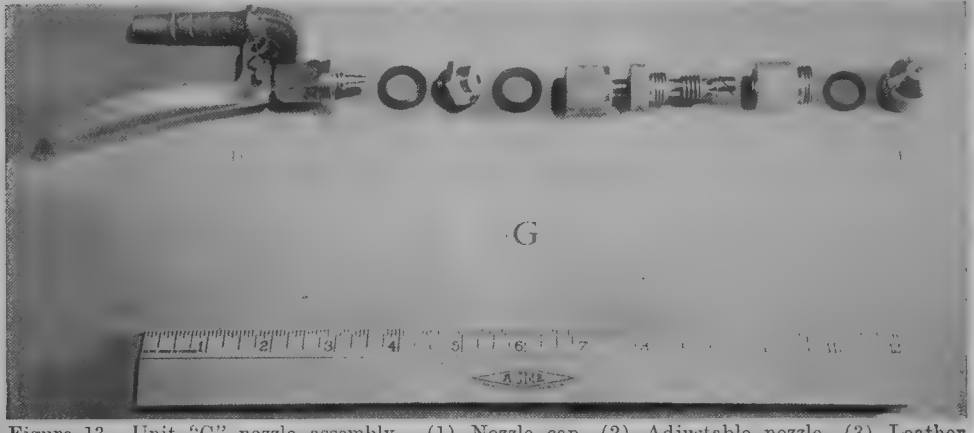


Figure 13. Unit "G" nozzle assembly. (1) Nozzle cap, (2) Adjustable nozzle, (3) Leather washer, (4) Outlet valve body, (5) Leather washer, (6) Trigger-operated valve pin, (7) Trigger.

TABLE 2. SPECIFICATIONS AND CHARACTERISTICS

—	Unit A	Unit B	Unit C	Unit D	Unit E	Unit F	Unit G
TANK							
Dimensions: (ins.)							
Height	17 7/8	15 1/2	13 3/4	12 1/4	14 7/8	14 7/8	17 1/4
Width	8 5/8	14	14 5/8	13 7/8	14	14	14 1/2
Depth	8 5/8	6 3/4	7 1/8	6 3/4	6 7/8	6 7/8	7 1/2
Overall height of unit	19 1/4	17	16 1/2	15 1/2	18	18	22 7/8
Weight: (lbs.)							
Tank only	6.6	8.2	9.3	9.5	8.9	8.9	10.8
Back-pack pump, empty	9.4	11.1	12.2	11.3	11.6	10.8	16.1
Back-pack pump, full	41.7	55.6	52.0	45.6	54.6	53.7	52.1
Ratio of water by weight to gross weight	0.77	0.80	0.77	0.75	0.79	0.80	0.69
Volume: (Imp. gals.)							
Capacity	3.2	4.4	4.0	3.4	4.3	4.3	3.6
Filling Opening: (ins.)							
Size	3 3/16	3 15/16	5 1/16 × 3/8	3 5/8	3 15/16	3 15/16	3 7/8
Distance from tank edge	2 3/4	13/16	1 1/8	7/8	1 1/8	1 1/8	11/16
Filling Opening Strainer:							
Type	screen cylinder	cylinder; perforated base	perforated tray	screen cone	cylinder; perforated walls & base	cylinder; perforated walls & base	screen cone
Attachment to tank	good	good	poor	fair	good	good	poor
Utility—preventing pump blockage	fair	poor	fair	poor	poor	poor	poor
—permitting rapid tank filling	good	fair	poor	good	fair	fair	good

TABLE 2. SPECIFICATIONS AND CHARACTERISTICS *(cont'd)*

—	Unit A	Unit B	Unit C	Unit D	Unit E	Unit F	Unit G
Piston Rings & Packing:							
Type	neoprene pist. ring; felt wiping ring	grease-impreg. pack. ring	grease-impreg. cord pack.	neoprene pist. ring; neoprene pack. ring	grease-impreg. cord pack.	leather pist. rings; leather pack.	rubber plunger cup
Utility	good	fair	fair	good	good	good	good
Pump Outlet Valve:							
Type	brass ball	brass ball	brass ball	brass ball	brass ball	brass ball	tapered pin in nozzle
Spring	steel	copper	copper	copper	copper	none	copper
Closing action	good	poor	good	fair	poor	poor	good
Nozzle:							
Type	straight stream	twin; straight & spray	straight stream	two stream, straight or spray	adjustable stream	adjustable stream	adjustable stream
Features	spray-tip attachment	poor chain attachment	depressor tongue for spray	single throw valve	see. Diag. 5	similar to Diag. 5	see Diag. 5
Performance							
Max. length of stream (ft.)	42	42	54	36	41	42	35
Effective length of stream (ft.)	32	34	42	27	31	32	25
Output per 25 pump cycles (gals.)	0.50	0.60	0.48	0.52	0.55	0.45	0.28
Frequency of nozzle blockages	none	occasional on straight stream; frequent on spray	none	frequent	frequent on spray stream	frequent on spray stream	occasional
Filling Opening Lid:							
Type	threaded	friction	clamp	threaded	threaded	threaded	clamp
Attachment to tank	none	cord	chain	chain	chain	chain	hinge

TABLE 2. SPECIFICATIONS AND CHARACTERISTICS *(cont'd)*

—	Unit A	Unit B	Unit C	Unit D	Unit E	Unit F	Unit G
Piston Rings & Packing:							
Type	neoprene pist. ring; felt wiping ring						
Utility	good						
Pump Outlet Valve:							
Type	brass ball						
Spring	steel						
Closing action	good						
Nozzle:							
Type	straight stream						
Features	spray-tip attachment						
Performance							
Max. length of stream (ft.)	42						
Effective length of stream (ft.)	32						
Output per 25 pump cycles (gals.)	0.50						
Frequency of nozzle blockages	none						
Filling Opening Lid:							
Type	threaded	friction	clamp	threaded	threaded	threaded	clamp
Attachment to tank	none	cord	chain	chain	chain	chain	hinge

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TABLE 2. SPECIFICATIONS AND CHARACTERISTICS (*concl'd*)

—	Unit A	Unit B	Unit C	Unit D	Unit E	Unit F	Unit G
Tank Outlet:							
Type	snap-on	nipple & clamp	nipple & clamp	snap-on	nipple & clamp	nipple & clamp	nipple & clamp
Position	top	near base	near base	top	near base	near base	top of piston
Strainer	none	none	wire screen	wire screen	perforated plate	perforated plate	none
Ease of maintenance	good	good	good	good	fair	fair	fair
Carrying Features:							
Pump clamp position	tank side	tank top	handle	handle	handle	handle	none
Ease in mounting unit on back	good	poor	poor	poor	poor	poor	good
Ease in removing pump from clamp (when unit on back)	good	poor	poor	poor	poor	poor	—
HOSE							
Type	reinforced rubber; supple	rubber; supple	reinforced rubber; stiff	plastic; stiff especially when cold	reinforced rubber; stiff	reinforced rubber; supple	reinforced rubber; supple
Length (ins.)	40	25	26	41	27	40	48
Fittings	snap-on	clamp	clamp	snap-on	clamp	clamp	clamp
PUMP							
Type	trombone single action	trombone single action	trombone single action	trombone double action	trombone continuous action	trombone double action	lever continuous action
Length—closed (ins.)	$17\frac{7}{8}$	$24\frac{3}{8}$	18	$17\frac{1}{2}$	27	$19\frac{1}{2}$	—
—open (ins.)	$32\frac{3}{8}$	39	$30\frac{5}{8}$	$28\frac{1}{2}$	$41\frac{1}{2}$	$23\frac{1}{2}$	—
Ease of operation	good	good	good	fair	good	fair	fair

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MACTAVISH J S
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PUMPS USED IN FOREST FIRE
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Mactavish, J. S.
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